Global Peer Pressure

How California, China & Europe Will Continue To Push The U.S. Towards Vehicle CO₂ Reduction

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Presentation Outline

• New Seven-Stars of Alignment Paradigm
• Global Regulations and Impact on Powertrain Options
  1. Right Amount of Electrification For the Right Region
  2. Regional 2025 Outlook
  3. ZEV Mandate
• VPaC Sales xEV Outlooks
• Autonomous Vehicles and New Definition of Mobility
• Summary
IHS Hybrid Nomenclature

ICE – ICE Stop/Start
Internal Combustion Engine
ICE w/Start-Stop functionality

FHEV
Vehicle capable of driving using only the electric motor and battery pack, in concert with ICE, or ICE alone

PHEV
Vehicle capable of driving using only the electric motor and battery pack, in concert with ICE, or ICE alone, but is equipped with a charger to allow for plug-in capability

Mild Hybrid
ICE w/electric motor & battery to provide torque assistance in concert with ICE

Electric
Vehicle propelled by battery and electric motor
The Seven Stars of EV Expansion

• No single factor will determine the fate of EVs

• The interrelated factors compound one another

• The automotive industry carries great inertia, overcoming it is a constant challenge

• Each global region balances these factors differently

  For example:
  
  Fuel prices / USA

  Regulation & Incentives / China and Europe

  Infrastructure / Japan
Technology needed to meet the regulations and current demand for such technologies

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>China</th>
<th>EU</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CAFE/GHG</td>
<td>CAFC</td>
<td>NEV</td>
<td>CO₂</td>
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<tr>
<td>FHEV</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>PHEV</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
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Consumer demand:
- **High**
- **Low but tends to grow**
- **Low and remains stagnant**
- **Low, and there are also difficult obstacles to boost the demand in the future**
- **Almost no demand**

Effect of efforts to meet the regulations:
- ✔: Some effect
- ✔ ✔: Much effect

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Global propulsion design islands in 2025

North America
- Stop-start: 3%
- ICE: 63%
- MHEV: 5%
- FHEV: 6%
- PHEV: 7%
- Electric: 16%

Europe
- Stop-start: 5%
- ICE: 60%
- MHEV: 6%
- FHEV: 21%
- PHEV: 7%
- Electric: 5%

China
- Stop-start: 5%
- ICE: 41%
- MHEV: 6%
- FHEV: 18%
- PHEV: 13%
- Electric: 20%

Japan/Korea
- Stop-start: 3%
- ICE: 44%
- MHEV: 16%
- FHEV: 13%
- PHEV: 5%
- Electric: 20%
Is California’s Zero Emission Vehicles Mandate the Missing CO₂ Piece?

Total ZEV Credit Percentage Requirement 2018+

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Source: CARB Advanced Clean Cars
### Are We There Yet?

<table>
<thead>
<tr>
<th>Level 1 Charging</th>
<th>Level 2 Charging</th>
<th>Level 3 Charging</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 5 miles of range per one hour of charging</td>
<td>10 to 20 miles of range per one hour of charging</td>
<td>50 to 70 miles of range per 20 minutes of charging</td>
</tr>
</tbody>
</table>

- **Compare to 3-5 minutes**
- **Gasoline**
- **Hydrogen**

Source: Alternative Fuels Data Center
Legislation: ZEV vs. CAFE & Right-sizing For Consumers

Zero-Emissions Travel

Driving Range – 300 Miles

- <100 Miles
- 1st Generation
- BEV
- >200 Miles
- 2nd Generation
- Emission-free driving

Open-Road Travel

- ~25 Miles
- EREV
- ~50 Miles

- ~50 Miles
- PHEV
- ~25 Miles
- FHEV

Vehicle speed, driver habits, weight, etc.
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Cumulative Expected EV Volumes
Global volumes from 2018–25 EV production

Source: IHS May 2017 powertrain forecast
"The capacity is not there. Nobody has the capacity", Thomas Sedran, VW's head of group strategy, said last month of the six largest global cell suppliers competing for the VW contract. ANE. Jan 2017

He estimated the capital expenditure needed to supply all of VW Group's EVs with in-house batteries at 20 billion euros. "We need to check whether [the six suppliers tendering for the cell contract] have the financial means to build the capacity", he added. ANE Jan 2017

"One weakness in our EV argument is that it currently requires battery supply that does not exist", Exane BNP Paribas. Jan 2017
Electric to account for nearly 3% of the PT landscape by 2025

<table>
<thead>
<tr>
<th>2025 Star</th>
<th>Positive/Negative for BEV</th>
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<td>Government/Legislation</td>
<td>+</td>
</tr>
<tr>
<td>Fuel Price</td>
<td>-</td>
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<td>R&amp;D/Life Cycle</td>
<td>+/-</td>
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<tr>
<td>Consumer Choices</td>
<td>-</td>
</tr>
<tr>
<td>Battery Density</td>
<td>+</td>
</tr>
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<td>Available Vehicles</td>
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<tr>
<td>Infrastructure</td>
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VPaC Electric Vehicle Powertrain Sales Forecast – EU28

Electric to account for nearly 5% of the PT landscape by 2025

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VPaC Electric Vehicle Powertrain Sales Forecast – China

Electric to account for nearly 5% of the PT landscape by 2025

### 2025 Star

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Compliance Landscape

Regulatory VPAC Compliance Passenger Car: 2025

- CAFE & GHG credits excluded

- The baseline does not envisage a softening or delay to the targets as part of the new final determination. More flexibilities and credits expected to be given to automakers

- All Manufacturers of Record could fall short without considerable credits and/or more electrification on high volume models.
All Manufacturers of Record could fall short in the LT category (again, CAFE and GHG credits excluded), which contains the most popular vehicles among U.S. consumers.

Manufacturers that are challenged will likely pursue a combination of considerably better conventional powertrain integration, plus greater electrification, focused on MHEV and PHEV that will not require a change of customer behavior; important in this market.
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BEV

GENERAL MOTORS

TESLA

LUCID

Faraday Future

Autonomous EV
Language defined – Real-world examples of SAE Levels

Autonomous = Level 4 and Level 5

<table>
<thead>
<tr>
<th>Level</th>
<th>Automation Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>L5</td>
<td>Full Automation</td>
<td>Fully autonomous driverless fleets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mobility service business model</td>
</tr>
<tr>
<td>L4</td>
<td>High Automation</td>
<td>Fully autonomous autopilots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drivers disengage in more situations</td>
</tr>
<tr>
<td>L3</td>
<td>Conditional Automation</td>
<td>Advanced autopilots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drivers intermittently re-engage</td>
</tr>
<tr>
<td>L2</td>
<td>Partial Automation</td>
<td>Autopilot Traffic jam assist</td>
</tr>
<tr>
<td>L1</td>
<td>Driver Assistance</td>
<td>Adaptive cruise control</td>
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<tr>
<td></td>
<td></td>
<td>Lane keep assist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Autonomous parking</td>
</tr>
<tr>
<td>L0</td>
<td>No Automation</td>
<td>Collision warning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lane departure warning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blind spot information</td>
</tr>
</tbody>
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Long-term, fully electric (including fuel cell) powertrains will be the desired propulsion source by Governments and Consumers.

Based on Society of Automotive Engineers levels of automation (SAE J3016)
Autonomous vehicle sales growth accelerates post-2025
Maturity of technology, manufacturing, regulation and business models converge

Global Autonomous Vehicle Sales Forecast

Source: IHS Markit June 2016
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Autonomous capability will blur the lines between today’s mobility business models and use cases.
Conclusion: Mega-Trend Outlook

Compliance
- EV adoption & energy

Autonomy
- Deployment of driverless

Mobility
- Mobility as a Service

Regulation pressure
Environment and climate
Energy rivalry
Societal change
Ride hailing

Technology development
Economic uncertainty
Autonomous
Connectivity

Source: IHS Markit
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Summary

• China and Europe continue vehicle CO₂ reduction initiatives
• Increased market penetration for PHEV and BEVs
• Global expansion of Ride sharing and Ride hailing
• Levels of Autonomy for vehicles favor all-electric powertrains

The Pressure

• U.S. Consumer’s desire for CUVs and Pick-up trucks
• Battery supply chain and charge times
• CAFE and ZEV standards
Thank You!

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